

**DESCRIPTIONS OF THE FINAL INSTAR LARVAE OF *ARGIA SABINO*
GARRISON AND *ARGIA PIMA* GARRISON (ODONATA: COENAGRIONIDAE)**

JON D. HOEKSTRA AND ROBERT L. SMITH

Department of Entomology, University of Arizona, Tucson, AZ 85721, U.S.A. (e-mail: bobsmith@ag.arizona.edu); (JDH) Current address: Illinois Natural History Survey, Center for Aquatic Ecology, 607 E. Peabody Dr., Champaign, IL 61820 (e-mail: hoekstra@mail.inhs.uiuc.edu).

Abstract.—We illustrate and describe the final instar larvae of *Argia sabino* Garrison 1994 and *Argia pima* Garrison 1994 based on preserved exuviae and larvae from Sabino Creek, Arizona, U.S.A. A dichotomous key is provided to integrate *A. sabino* and *A. pima* into an existing larval key to North American *Argia* spp.

Key Words: Arizona, damselflies, Zygoptera, larval taxonomy, *Argia*

Argia sabino Garrison is a species of conservation concern because of its limited range and possible endemism. The species is known from only three localities globally and from only one U.S. breeding population at Sabino Creek, Arizona (Garrison 1994). *Argia pima* Garrison is closely related to *A. sabino* and the two species are sympatric at Sabino Creek. Here we describe the final instar larvae of both species. This project was undertaken in support of studies on the habitat requirements of *A. sabino*.

Argia is a diverse odonate genus, containing about 110 species (Garrison 1994). The larvae of the genus are poorly known. Of 36 North American *Argia* spp., Westfall and May (1996) provide a key to identify the larvae of 29 species. Larvae of only 28 *Argia* spp. have been formally described (Novelo-Gutierrez 1992). Continued progress in describing larvae will benefit our understanding of the evolution and systematics of the group. In addition, development of comprehensive larval keys to *Argia* will facilitate ecological studies of benthic invertebrates in many habitats. Frequently, several species of *Argia* are sympatric in

small streams, particularly in the southwestern U.S. and southward into the Neotropics. For example, eleven *Argia* species are known from Sabino Canyon (R.W. Garrison, personal communication). At any given time or location, up to eight of the Sabino Canyon species may be common or quite abundant (personal observation).

Our descriptions include a treatment of the male and female gonapophyses, which Novelo-Gutierrez (1992) showed to be highly diverse and taxonomically useful structures within the genus. We also provide a diagnosis of the larvae, and integrate the two species into Westfall and May's (1996) key to North American *Argia* larvae.

METHODS AND MATERIALS

Argia larvae in all stages of development were collected from Sabino Creek, Arizona, U.S.A. in May 1996 and from March to July 1997. Collections were made with a standard D-frame aquatic collecting net from shallow areas of pools, primarily by lifting or turning rocks and scooping up dislodged substrate and invertebrates. The net was also swept among submerged root mas-

ses and leaf litter. *Argia* larvae were maintained at 20°C on a 14:10 (L:D) cycle in 120 ml plastic specimen containers that were supplied with a strip of cordura nylon webbing as a clinging substrate. Larvae were fed mosquito larvae, *Daphnia*, ostracods, and tubificid worms *ad libitum* (late-instars were primarily fed tubificid worms) until they emerged. Final stadia ceased feeding when emergence was imminent. At this time, each larval container was provided with an emergence stick and placed in an emergence chamber (inverted 3.8-liter glass condiment jar) to contain the imago. All exuviae and some larvae were preserved in 80% EtOH. Teneral adults were allowed to harden until they could be identified and then were preserved in 80% EtOH with the associated larval exuviae. We measured exuviae and larvae with a Lasico model S-4 auto-scaler. Illustrations were prepared with a camera lucida at 12× (dorsal habitus), 25× (prementum and lamella), and 50× (gonapophyses) magnification.

DESCRIPTIONS

Argia sabino Garrison 1994 (Figs. 1–5)

Final instar larva.—Robust; ground coloration pale to medium brown; markings deep brown to black. Measurements presented in Table 1. *Head*: Dorsum of head patterned as shown (Fig. 1). Ocelli visible as white semicircular depressions. Cephalic lobes with dorsum irregularly patterned; posterolateral margins of lobes broadly angulate, darkly pigmented, and with a fringe of stout setae. Antenna 7-segmented; scape broad, short with apical fringe of fine setae; pedicel longer, broad with rounded apex; remaining segments elongate. All segments light brown. Antennomere lengths (from basal to distal) approximately as 0.4: 0.7: 1.0: 0.9: 0.5: 0.3: 0.1. Labium pale to medium brown. Prementum (Fig. 2a) with stout setae along distal 0.4 of lateral mar-

gins, a cluster of 3–8 basidorsal stout setae, and a series of 3–7 fine, short dorsoapical setae; basidorsal and dorsoapical setae sometimes absent. Ligula strongly to moderately prominent, with closely set minute claviform setae along margin. Premental palpus with 3 (sometimes 2) long dorsal hairlike setae; dorsal movable hook (brown) and pair of ventral hooks present; the ventral pair longer than dorsal hook and tinged with brown. *Thorax*: Pronotum with scattered stout setae and usually a pair of dorsal spots. Lateral pronotal margins produced with clump of stout setae. Synthorax relatively dark with obscure patterning. Wing sheaths with dark bands as shown in Fig. 1; tips of posterior pair typically extend to the posterior margin of abdominal tergite 4. Sternites unpigmented with scattered fine setae and a single long fine seta anteromesal to each mesocoxa. Femora with 2 dark transverse bands each, the distal band larger; bands narrower than intervening spaces. Profemur with regularly spaced stout setae along posterior, anterior, dorsal, and ventral margins; stout setae fewer in similar positions on meso- and metafemora. Tibiae with dark transverse band slightly basal to center and usually with dark area near articulation with femora. Tarsi 3-segmented, light brown, with pair of strongly curved claws. Tibiae and tarsi with thick dorsal growth of long fine setae. Stout setae along ventral margin of tibiae; setae increasing in extent and number to form dense patch near apices. Several setae near apices trifurcate, comblike. Ventrally directed, finer stout setae present in two rows along ventrolateral edges of tarsi. *Abdomen (excl. appendages)*: Abdominal tergites 1 and 2 usually unpatterned; 3 and 4 variable, often with irregular dark patterns; 5–7 with dorsolateral and lateral dark blotches paired about dorsal midline, these blotches continuous with posterior margin and tapering anteriorly in tergum 7; 8 and 9 primarily deep brown with light areas centered on midline and tapering abruptly to thin line posteriorly; 10 notched with lateral faces dark and broad

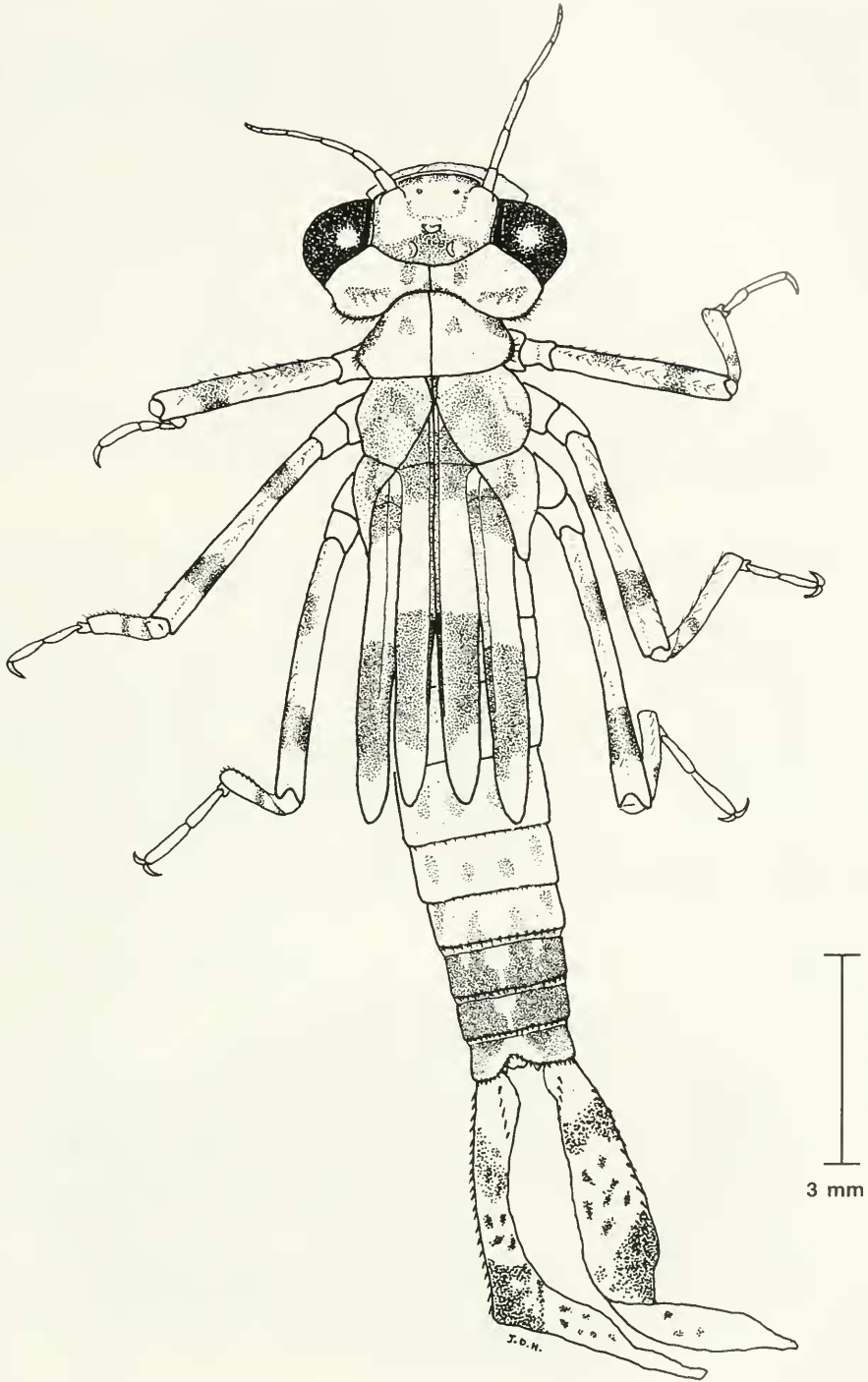


Fig. 1. Dorsal habitus of final instar larva, *Argia sabino*.

Table 1. Measurements* of final instar larvae, *Argia sabino* and *Argia pima*.

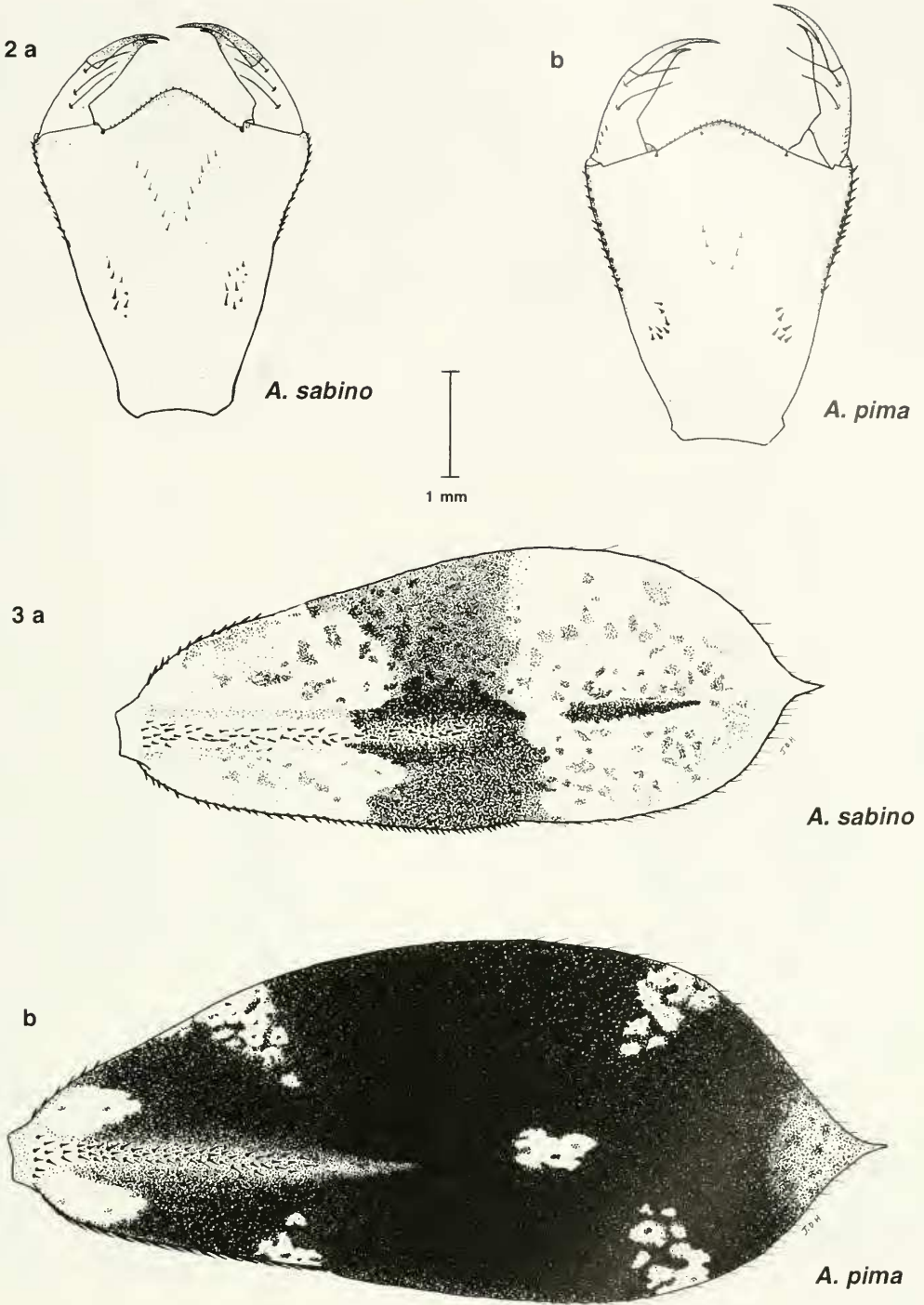
| | Head Width | Total Length | Hind Femur Length | Hind Wingpad Length | Lateral Lamella Length |
|---------------------|------------------------|----------------------------|------------------------|------------------------|------------------------|
| <i>Argia sabino</i> | | | | | |
| Males (n = 5): | 3.4–4.0 (3.7 ± .23) | 11.7–15.2 (13.1 ± 1.4) | 3.7–4.2 (4.0 ± .25) | 3.9–5.0 (4.5 ± .55) | 5.4–6.5 |
| Females (n = 9): | 3.4–3.8 (3.6 ± .08) | 11.1–16.4 (13.9 ± 1.1) | 3.6–4.3 (4.1 ± .15) | 4.3–5.0 (4.7 ± .12) | (6.0 ± .23; n = 8) |
| <i>Argia pima</i> | | | | | |
| Males (n = 7): | 3.9–4.1 (4.0 ± .06) | 12.7–17.7 (14.8 ± 1.47) | 4.0–4.5 (4.2 ± .25) | 4.4–4.8 (4.6 ± .08) | 6.2–7.8 |
| Females (n = 8): | 3.9–4.1 (4.0 ± .06) | 12.7–16.9 (14.7 ± 1.22) | 4.2–4.6 (4.4 ± .11) | 4.6–5.2 (4.9 ± .15) | (7.0 ± .40; n = 7) |

* Range in mm; mean ± 90% confidence half-interval in parentheses. Measurements for lateral caudal lamella length not reported by sex. Total length excludes caudal lamellae. Not all specimens examined were measured because some were damaged or distorted.

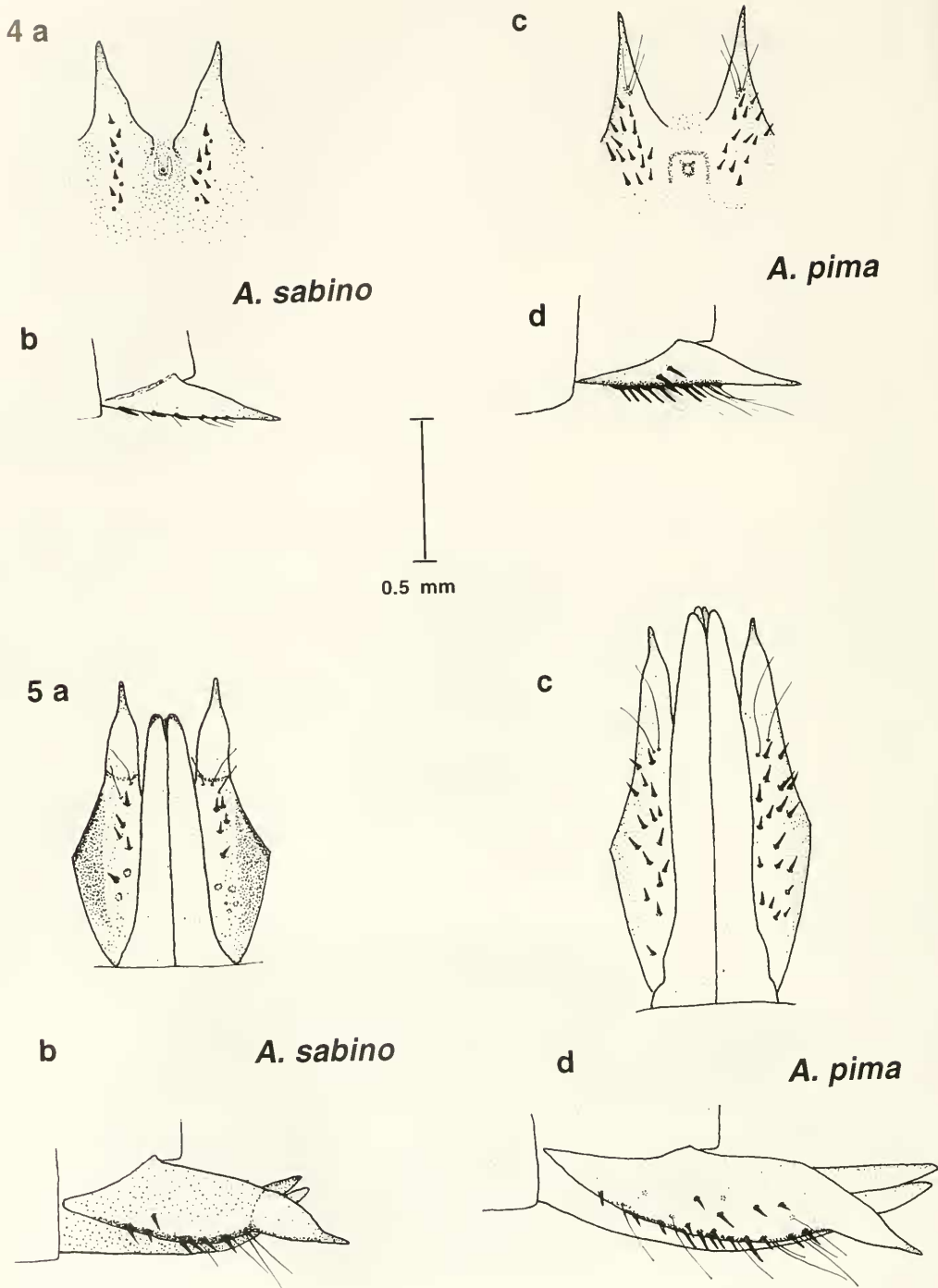
pale area centered on dorsal midline. Tergites 1–4 clothed with long fine setae, without stout setae; 5–10 with fewer fine setae and increasing densities of stout setae; stout setae particularly prominent along posterior margins of 8–10. Lateral pleura of segments 3–10 with stout setae increasing in size and density on posterior segments. Sternites 1–6 unpigmented with sparse fine setae; 7–10 progressively darker with increasing densities of stout setae especially along posterior margins. *Caudal lamellae*: Caudal lamellae laminar (slightly inflated basally) with moderately acuminate tips. Lateral lamellae (Fig. 3a) 2.5 times as long as wide with lateral external carinae extending along basal 0.5 of length of lamella and bearing stout setae; stout setae present along basal 0.1 and 0.6 of dorsal and ventral margins, respectively. Median caudal lamella less than twice as long as wide and without lateral carina; analogous central lamellar keel without stout setae. Median lamella with stout setae along basal 0.4 and <0.1 of length of dorsal and ventral margins. Lateral lamella largely pale with scattered dark spots or mottling except for black transverse band covering mesal $\frac{1}{4}$ – $\frac{1}{3}$ of lamella, centered on terminus of lateral carina. Band darkest ventrally, fading to a broken area of dark spots dorsally in some specimens. Median caudal lamella with central transverse

band less prominent than in lateral lamellae, and usually with more extensive mottling on distal and basal ends of gill. *Gonapophyses and cercus*: Male gonapophyses (Figs. 4a, b) light brown, pyramidal to elongate, with acute tips parallel and extending to posterior 0.4 of sternite 10. Basal 0.6 of venter of gonapophyses with series of 4–8 principal and a few smaller stout setae directed posteriorly and closely appressed; a few fine setae also present. Male cercus without prominent distal points; inner margin convex in dorsal view; distance between cerci in dorsal view less than or equal to their maximum width. Female gonapophyses (Figs. 5a, b) with acute tips of outer pair parallel to slightly divergent and extending to posterior 0.8 of tergum 10. Tips of inner pair extend to posterior 0.8 of outer pair in ventral view. Basal 0.7 of venter of outer pair with series of 5–10 principal and several smaller stout setae; fine setae also present.

Remarks.—Characters relating to relative extensions of structures (e.g. extension of wing sheaths relative to abdominal tergite 4) are variable due to differences in posture and extension of preserved specimens. Body patterns may be obscure in very dark or pale individuals; pigmentation patterns are much more distinct in preserved larvae than in exuviae. The above description is



Figs. 2-3. Labium and lateral lamella. 2. Prementum, dorsal view; a, *Argia sabino*, b, *A. pima*. 3. Left lateral lamella, lateral view; a, *A. sabino*, b, *A. pima*.



Figs. 4-5. Gonapophyses. 4. Male gonapophyses in ventral (a, c) and lateral (b, d) view; a, b. *Argia sabino*, c, d. *A. pima*. 5. Female gonapophyses in ventral (a, c) and lateral (b, d) view; a, b. *A. sabino*, c, d. *A. pima*.

based on the following specimens: U.S.A., Arizona, Pima County, Santa Catalina Mts., Sabino Creek, under stones and in detritus in pools. Collected at 990–1,190 m on various dates, IV-10-97–VII-10-97. Exuviae: 3 males, 4 females, Florida State Collection of Arthropods, International Odonata Research Institute (FSCA/IORI); 2 males, 3 females, University of Arizona Insect Collection (UAIC). Larvae: 1 male, 3 females, FSCA/IORI; 1 male, 2 females, UAIC.

Argia pima Garrison 1994
(Figs. 2–6)

Final instar larva.—Similar in overall habitus to *A. sabino* but larger (Table 1) and slightly more elongate; ground coloration usually darker than in *A. sabino*, medium brown; markings deep brown to black (Fig. 6). *Head*: Patterns on dorsum of head similar to those in *A. sabino*, but less distinct. Ocelli, antenna, overall shape of head, and setation and shape of cephalic lobes as in *A. sabino*. Antennomere lengths approximately as 0.4: 0.7: 1.0: 0.8: 0.6: 0.2: 0.15. Labium pale to light brown; prementum (Fig. 2b) with stout setae along distal 0.5 of lateral margins, a cluster of 6–10 basidorsal stout setae, and usually with 1–3 dorsoapical fine setae; these less prominent than in *A. sabino*. Ligula moderately prominent; minute claviform setae set along apical margin; an additional pair of minute claviform setae also present, recessed from margin of ligula. Premental palpi usually with 2 hairlike setae, rarely with 3 on one palpus; palpal hooks as in *A. sabino*. *Thorax*: Pronotum with scattered stout setae but lacking pair of dorsal spots. Lateral pronotal margins with prominent knob covered with stout setae. Synthorax and wing pad patterns as in *A. sabino*; tips of posterior pair of wing pads typically extend to posterior margin of abdominal tergite 3. Sternites pale with scattered fine setae. Pigmentation and setation patterns of legs as in *A. sabino*, except dark areas on tibiae near articulation with femora usually more extensive and distinct. *Abdomen (excl. ap-*

pendages): Setation of abdominal tergites as in *A. sabino*. Abdominal color pattern similar to that of *A. sabino*, except white areas on dorsum of tergites 8 and 9 not narrowing posteriorly. Abdominal tergites 1 and 2 mostly pale; 3–5 with dark lateral areas and a paler bilobed marking centered on dorsal midline; 6–7 with dorsolateral and lateral dark blotches paired about dorsal midline, these blotches often continuous with posterior margin and tapering anteriorly on 7; 8 and 9 primarily deep brown with light stripe centered on midline; 10 notched with lateral faces dark and broad pale area centered on dorsal midline, this pale dorsal stripe widening posteriorly. Stout setae present along lateral pleura of segments 3–10. Setation and coloration of sternites as in *A. sabino* except stout setae less robust and abundant, especially on 8. *Caudal lamellae*: Caudal lamellae saccoid-laminar, basally inflated to a greater degree than in *A. sabino*, with moderately acuminate tips. Lateral lamellae (Fig. 3b) 2.5 times as long as wide with lateral external carinae extending along basal 0.4 of length of lamella and bearing stout setae; stout setae present along the basal 0.1 and 0.4 of dorsal and ventral margins, respectively. Median caudal lamella without lateral carinae; analogous lengthwise keel with a few stout setae near base of gill; stout setae along basal 0.2 and 0.15 of dorsal and ventral margins. Lateral lamellae largely velvety black; with light areas at basal 1/10 and a small pale spot roughly at center of gill; distal dorsal and ventral edges of gill often with mottled, wedge-shaped areas converging on pale central spot (Fig. 3b). In some individuals, mottled areas nearly reach central spot. Median caudal lamella similar in pigmentation to lateral lamellae, but with markings more diffuse and with light areas more extensive than in lateral lamellae. *Gonapophyses and cercus*: Male gonapophyses (Figs. 4c, d) light brown, more elongate than those of *A. sabino*, with acute tips parallel and extending to posterior 0.4 of tergum 10. Basal 0.7 of venter

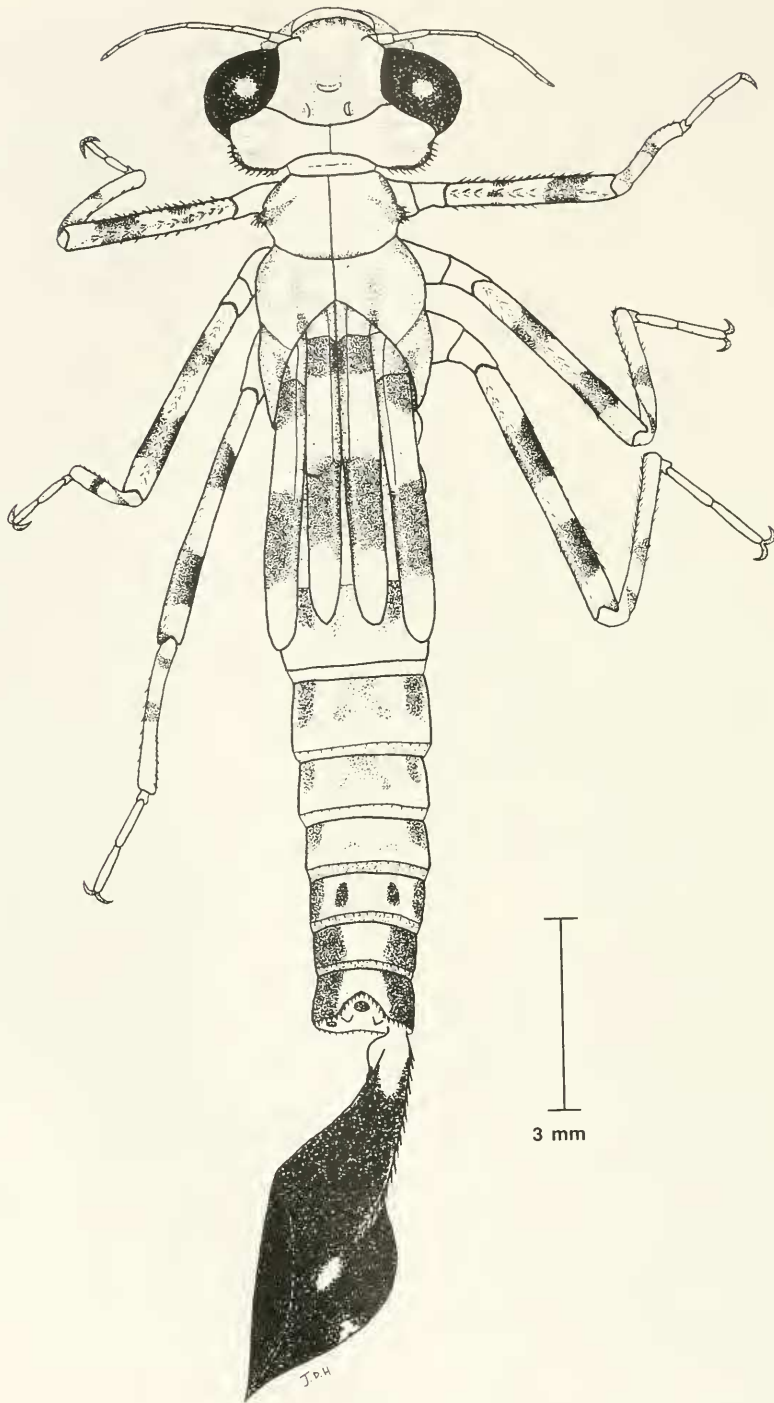


Fig. 6. Dorsal habitus of final instar larva, *Argia pima*.

of gonapophyses with series of 10–15 principal and several smaller stout setae directed posteroventrally; 2–4 fine setae also present. Male cercus as in *A. sabino*, except distance between cerci in dorsal view usually greater than their maximum width. Female gonapophyses (Figs. 5c, d) with acute tips of outer pair slightly divergent and extending beyond end of tergum 10. Tips of inner pair extend to or beyond tips of outer pair in ventral view. Basal 0.8 of venter of outer pair with series of 15–20 principal and several smaller stout setae; 6 principal and several smaller fine setae also present.

Remarks.—Variability noted for *A. sabino* also exists in *A. pima*. In particular, extension of abdominal segments may be extreme in specimens preserved *post mortem*. Some individuals are very darkly pigmented. The above description is based on the following specimens: U.S.A., Arizona, Pima County, Santa Catalina Mts., Sabino Creek, under stones and in detritus in pools. Collected at 1,100–1,190 m on VI-6-96 and on various dates, III-17-97–VII-10-97. Exuviae: 3 males, 4 females, FSCA/IORI; 2 males, 2 females, UAIC. Larvae: 1 male, 4 females, FSCA/IORI, 4 females, UAIC.

DIAGNOSIS

Larvae of *A. sabino* and *A. pima* could not be integrated into the larval key of North American *Argia* (Westfall and May 1996) without modifying couplet 16 and subsequent couplets. We restructured the key, based on published information, to accommodate *A. sabino* and *A. pima*. The key below is valuable primarily in determining specimens collected from southern Arizona and Mexico. All figures referred to are contained in this publication.

KEY TO NORTH AMERICAN ARGIA LARVAE
(After Westfall and May 1996)

- 1. Lateral gills with marginal fringe of stout setae for at least ¾ their length on both the ventral and dorsal margins (taxa not included here)
- 1'. Lateral gills with marginal fringe of stout setae extending at most about ⅓ the

- length of the ventral margin only, much less on dorsal margin, sometimes nearly lacking 15
- 15(1'). Lateral gills with a fringe of stout setae extending along at least the basal ⅓ of the ventral margin 16
- 15'. Lateral gills with ventral setae absent or restricted to the basal ¼ of the ventral margin (taxa not included here)
- 16(15). Usually with 2 palpal setae; lateral gills either primarily dark or pale with a dark medial band and stout setae along basal ½ of dorsal edge of gill 17
- 16'. Usually with 3 or 4 palpal setae; lateral gills either primarily pale with dark mottling or pale with brown speckles, but not as above 20
- 17(16). Lateral gills more than 2.25× as long as wide; spiniform setae on at most basal 0.2 of dorsal margin; gill surface primarily dark with restricted light areas 18
- 17'. Length of lateral gills subequal to 2× their width; spiniform setae on basal ½ of dorsal margin; gill usually mostly pale with dark medial transverse band . . . *munda*
- 18(17). Lateral gills almost uniformly dark; dorsum of abdomen either unmarked or with continuous broad pale dorsal stripe . . . 19
- 18'. Lateral gills primarily dark, but with pale basal area, central pale spot, and sometimes irregular pale areas as in Fig. 3b; dorsum of abdominal segments 9 and 10 with pale dorsal stripe, other segments variously patterned but without continuous dorsal stripe (Fig. 6) *pima*
- 19(18). Ligula barely prominent, distinctly less convex than in *A. pima* (Fig. 2b); abdomen with broad, continuous pale middorsal stripe *lacrimans*
- 19'. Ligula moderately prominent, at least as convex as in *A. pima* (Fig. 2b); dorsum of abdomen largely pale and without dorsal stripe *tonto*
- 20(16'). Lateral gills 2.5–3× as long as wide, primarily pale but with extensive dark mottled areas or dark transverse bands; femora distinctly banded with bands narrower than spaces between them 21
- 20'. Lateral gills 2× as long as wide or less, surfaces pale with brown speckles; femora not distinctly banded or bands wider than intervening spaces *alberta*
- 21(20). Abdomen with distinct, continuous, pale middorsal stripe 22
- 21'. Abdomen without a distinct pale middorsal stripe for its entire length; pale stripe usually present on segments 8–10

- but does not extend through anterior segments (Fig. 1) *sabino*
- 22(21). Lateral gill widest at or just beyond $\frac{1}{2}$ its length, diffusely mottled (sometimes with faint transverse bands) *anceps*
- 22'. Lateral gill widest at about $\frac{3}{4}$ its length, with 2 or 3 well-marked transverse bands *tarascana*

DISCUSSION

Argia sabino is very similar in adult morphology to *A. tarascana* Calvert, its sister species (Garrison 1994). The larvae of *A. tarascana* (Westfall 1990, Novelo-Guiterrez 1992) are similar to those of *A. sabino* as well, but in addition to the difference in abdominal color pattern described above, there also is a structural difference in female gonapophyses (especially as seen in lateral view). A parallel situation exists for *A. pima*; its sister species is *Argia lacrimans* Hagen (Garrison 1994). The larvae of these species are fairly distinct; beyond the characters used in our key, differences in the abdominal color pattern and the shape and setation of the male gonapophyses also distinguish the two species (compare with figures for *A. lacrimans* in Novelo-Guiterrez 1992).

Separating larvae of *A. sabino* and *A. pima* is an important objective for ecological and conservation studies in Sabino Canyon. No characters have been found to separate early-instar larvae of the two species, but for mature larvae this determination is not difficult provided well-formed lamellae are present. Lamellae are frequently absent or in early stages of regeneration in late-instar larvae. In this case, female larvae can be separated by a character of the gonapophyses: the inner pair of gonapophyses extends to the tips of the outer pair or beyond in *A. pima* (Figs. 5c, d), whereas the inner pair is recessed in *A. sabino* (Figs. 5a, b). Separation of males without lamellae is more difficult. In *A. pima*, the distance between the pharate cerci usually exceeds

their width; in *A. sabino*, this gap is usually subequal to or less than the width of the cercus. Second, the stout setae on the gonapophyses of *A. sabino* are relatively few (fewer than 12 principal setae) and small. Stout setae are more numerous (more than 12 principal setae) and larger on the gonapophyses of *A. pima*.

ACKNOWLEDGMENTS

This work was funded partially by the U.S. Fish and Wildlife Service Ecological Services Office, Phoenix, Arizona. Thanks go to Carole McIvor of the University of Arizona School of Renewable Natural Resources for her initial work to obtain funding for this research. Thanks also to Lorena Wada of the U.S.F.W.S. Ecological Services Office for continuing interest in the project. The staff of the Coronado National Forest provided access and permits necessary to complete this research. The first author thanks the University of Arizona Department of Entomology and the ARCS (Achievement Rewards for College Scientists) Foundation for financial support during the time in which this work was completed. Hoekstra also thanks his wife, Tina L. Carrington, for assistance with fieldwork and for moral support necessary to complete this work.

LITERATURE CITED

- Garrison, R. W. 1994. A synopsis of the genus *Argia* of the United States with keys and descriptions of new species, *Argia sabino*, *A. leonorae*, and *A. pima* (Odonata: Coenagrionidae). Transactions of the American Entomological Society 120: 287-386.
- Novelo-Guiterrez, R. 1992. Biosystematics of the larvae of the genus *Argia* in Mexico (Zygoptera: Coenagrionidae). Odonatologica 21: 39-71.
- Westfall, M. J. 1990. Descriptions of larvae of *Argia munda* Calvert, *A. plana* Calvert, *A. tarascana* Calvert, and *A. tonto* Calvert (Zygoptera: Coenagrionidae). Odonatologica 19: 61-70.
- Westfall, M. J. and M. L. May. 1996. Damselflies of North America. Scientific Publishers, Gainesville, Florida, U.S.A. 649 pp.